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LERWICK OBSERVATORY

By W. G. HARPER, M.Sc.

With an historical introduction by Dr. A. H. R. Goldie

Historical.—The Observatory was opened in 1921 by the Meteorological Office, primarily as a magnetic observatory. On Dr. Crichton Mitchell, at that time Superintendent of the Office in Edinburgh, and Mr. J. Crichton, the first officer in charge at Lerwick, fell the chief burden of the initial set-up, at a time when the shortages arising from the 1914–18 war had not been overcome and the difficulties associated with economy cuts were just beginning.

To explain why it had for some years been regarded as specially important to have a magnetic observatory in Shetland, one must go back some way in time.

Half a century ago it was known that the earth's magnetic field was undergoing a gradual change (secular change), also that there were regular diurnal variations of the components of magnetic force varying with the seasons, and further that there was at times irregular disturbance—magnetic storms. An important practical use for continuous magnetic records lay therefore in the reduction of the results of magnetic surveys to a common base or epoch and this of course is still the case. At the time Rücker and Thorpe were engaged on their great work[1]* on the magnetic survey of the British Isles for the epoch 1891; it was, however, supposed that both the regular diurnal variation and the disturbance vectors could be regarded as practically invariable in amplitude within the region of the British Isles. As the late Dr. Chree[2] said " The hypothetical nature of these conclusions was clearly recognized by Rücker and Thorpe but they believed them sufficiently good approximations to the truth to justify their referring all their field observations to a single base station, Kew Observatory, in the south of England . . . "

As soon, however, as records became available from Eskdalemuir, it was obvious that natural magnetic disturbance was considerably larger than at Kew, and the desirability of records from a British station a good deal to the north of Eskdalemuir was gradually recognized.

Later it was found that at times of magnetic storms, the displacements of magnetic force from its normal value were on the average actually about twice as great at Eskdalemuir as at Abinger, the magnetic station in Surrey which

* The index numbers refer to the list of references on p. 314.

replaced Greenwich, although Eskdalemuir is less than 300 miles north of Abinger. And in turn the displacements at Lerwick, 330 miles further north, were found to be usually more than twice as great as those at Eskdalemuir. Thus not only were three magnetic observatories needed to permit exact survey work in the British Isles, but it was soon appreciated that the data of three observatories, roughly on a north-south line, offered a special opportunity for research on the position and pattern of the electric-current systems associated with magnetic disturbance. And of these observatories it seemed that Lerwick had a special value as being apparently near the latitude where the electric-current systems reach their greatest concentration.

When adequate recordings had accumulated, it was possible to compute that the principal concentration of electric current lay as a rule several hundred miles northward of Lerwick, but that it sometimes came actually a little to the southward of Lerwick, just as the aurora was sometimes seen to come southward of the zenith there. The height of this current was found to average about 100 Km. in winter, but at other times of the year it appeared to be more diffuse and centred at a greater height—some 300 Km. The magnitude of the current ranges up to 300,000 amp. or more in very great storms. In a modest storm in winter or in a magnetically quiet year it may be only some 50,000 amp.

Buildings and site.—Surrounded by peaty heather-covered moorland with scattered lochs, the Observatory stands on a ridge of high ground about 280 ft. above sea level. The buildings have a very open exposure, obtaining slight shelter from only one direction, where Shurton Hill rises a further 300 ft. about a mile away to the west-north-west. Lerwick, the county town and chief port of Shetland, 2½ miles away by road, has a frequent boat service direct to Aberdeen.

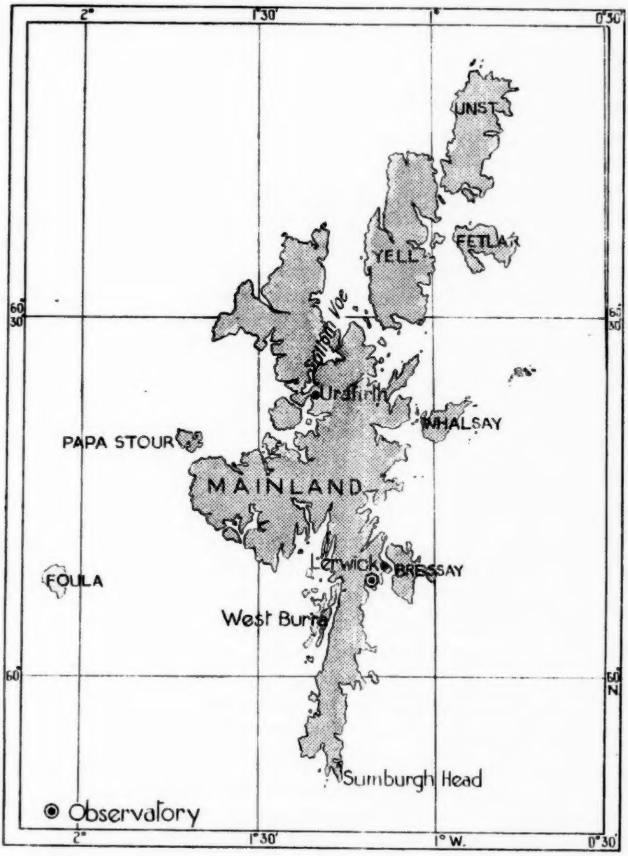
The main buildings, originally a wireless station built in 1913 by the Admiralty, became the Observatory offices and also house the staff.

Magnetic equipment.—The concrete hut built for the standard recording magnetographs lies about 300 yd. south-east of the main Observatory buildings on the open hill-side. It has walls nearly two ft. thick, designed to keep temperature variations to a minimum. Nearby wooden huts house the auxiliary recording magnetographs and the absolute magnetometers.

The main recording magnetographs are a La Cour standard set, originally used by the British Polar Year expedition at Fort Rae in 1932–33. The set has three components for horizontal force *H*, declination *D*, and vertical force *V*, arranged to record on a single drum of photographic paper 30 cm. wide, with a time scale of 15 mm./hr. These instruments were specially designed at Copenhagen for recording the wide ranges in the magnetic elements which occur in polar regions. An ingenious series of 18 reflecting prisms is used to multiply the range of record. The prisms give a series of reflected traces, adjusted so that, as one light spot moves off the photographic paper in a magnetic disturbance, the next reflected spot moves on to continue the record.

An older set of magnetographs, which had been in use as standard recorders until 1934, is installed in a separate hut as an auxiliary set. They also record photographically, and comprise a Munro *H*, a Munro *D* and a Watson quartz-fibre *V* which had been made specially for Lerwick some years earlier. The Munro magnetographs had been in use at Falmouth until 1912.

Installed in the concrete hut, in addition to the La Cour standard instruments, is a La Cour quick-run set, which also had been in use at Fort Rae. With a time-scale of 3 mm./min. (12 times as open as the standard traces) these records are used for timing sudden disturbances accurately. Some of these disturbances, associated with the onset of magnetic storms, are recorded by magnetographs all over the world. The general principles of the quick-run magnetographs are similar to those of the La Cour standard set, but 50 reflecting prisms are employed, each requiring separate adjustment.



MAP SHOWING THE POSITION OF LERWICK OBSERVATORY IN SHETLAND

Absolute magnetic observations are made three times weekly, using a Kew unifilar magnetometer for *D*, a Schuster-Smith coil magnetometer for *H*, and a Copenhagen balance magnetometer for *V*. In accordance with modern practice the two latter instruments are checked periodically against other observatories, using as travelling standards a quartz horizontal magnetometer and zero balance magnetometer, also recently developed at Copenhagen.

H and V can be measured almost to 1γ with these instruments ($1\gamma = 0.00001$ c.g.s. units of magnetic intensity). As normal values for H and V at Lerwick are $14{,}350\gamma$ and $47{,}000\gamma$, the refinement of these magnetometers can be appreciated. Hourly values are measured from the magnetograms, and indices of the degree of magnetic disturbance (K indices and C figures) are evaluated in accordance with international arrangements.

Auroral work.—The detailed study of auroræ was one of the primary purposes for establishing the Observatory, and ever since its opening a regular auroral watch has been maintained. It is kept normally from dusk until 10 p.m., and is continued if the aurora is still active. Few auroral displays commence after 10 p.m., but if one is seen, the trained observer is called out. In summer the light evenings make observation of all but intense auroral activity impossible. In spite of the fact that, for almost half the time in Shetland, observation is limited by overcast cloud, auroræ are reported on between 40 and 80 nights each year.

Work in auroral photography has been done intermittently to supplement the visual records, while during the Polar Year 1932–33 simultaneous auroral photographs were taken, whenever possible, at the Observatory and at Urafirth about 26 miles to the north. Urafirth was selected because the line between it and Lerwick is roughly perpendicular to the most frequently occurring direction of auroral arcs. This work was limited even more severely by cloud conditions.

Atmospheric electricity.—Records of the potential gradient of atmospheric electricity have been maintained continuously since 1926 with a Benndorf electrograph. The insulated collector of the electrograph is a copper rod tipped with polonium, which projects from the wall of the main office building almost five metres above the ground.

The electrograph, which has a scale value of about 32 v./mm., has a range of recording of $\pm 2{,}000$ v./m., yet these values are frequently exceeded when precipitation is falling on the collector. The record consists of a series of dots made once a minute on a recording drum. Insulation and scale tests of the system are made daily with a Wulf electrometer.

Hourly values measured from this record are reduced to absolute values by comparison against observations made with the Wulf electrometer. A stretched wire and polonium collector a metre above level ground clear of all Observatory buildings, are used for these measurements.

Radio-sonde.—The work of the Observatory, and the number of its staff, increased greatly with the introduction of radio-sonde work in 1940, and Lerwick has become a vital part of the network of land stations and ocean weather ships which make regular upper air observations.

Upper air temperatures and humidities are measured well into the stratosphere with the Meteorological Office pattern radio-sonde, while radar now is used for the measurement of upper winds. With light or moderate upper winds, reports are usually limited only by the bursting of the balloon, but with strong upper winds, frequently by the limit of range of the radar set.

From 1942 until 1946 radio direction-finding methods were used for the measurement of upper winds.[3] The Observatory was the launching site for the radio-sonde, while D/F sites were located at Ness of Sound, 1¼ miles

east-south-east, at Walls, 16 miles west-north-west, and at Brough, 24 miles north of the Observatory. Necessarily chosen for their freedom from electrical interference, these sites were inevitably in isolated localities, and at times great difficulty was experienced in supplying and manning them. On one occasion in 1945, when the detachment of two men at Walls was cut off completely by snow-drifts and several attempts at relief had failed, rations were dropped by air. The introduction in 1946 of radar methods for the measurement of upper winds made the D/F sites unnecessary and disposed of these problems.

Since 1943 a full programme, with radio-sonde and D/F or, later, radar-wind observations every six hours, has been maintained. Despite the very high frequency of gales in the winter months, no radar-wind observations were missed in 1948 and only one radio-sonde observation. This is no small tribute to the equipment provided and to the keenness and efficiency of the staff.

Meteorological records.—The Observatory is also a fully equipped climatological station, with a Dines pressure-tube anemometer, a float barograph and a microbarograph, in addition to the more usual equipment of an observing station. Hourly weather observations are made and dispatched to the Central Forecasting Office at Dunstable by teleprinter.

A night-sky camera, which records the periods during which the pole star is unobscured by clouds, is operated for nine months of the year. In summer the nights are too light to justify its use.

Other geophysical work.—The Observatory is intended to facilitate any geophysical research work for which its position renders it specially suitable.

It may be of interest to record that it was associated with some of the early work in radio direction-finding, and in the location of atmospherics (now commonly known as " sferics "). Direction-finding equipment was in operation in 1923, while atmospherics were recorded for the Department of Scientific and Industrial Research from 1924 until 1929. The three stations employed in this work were the Radio Research Station at Ditton Park near Slough in Buckinghamshire, Lerwick 600 miles to the north and Aboukir in Egypt, 2,000 miles to the south-east.

Between 1921 and 1928 work was done on the luminosity of the night sky, and in auroral spectroscopic photography. The work was initiated by the late Lord Rayleigh, who himself visited the Observatory soon after its opening, bringing a set of three instruments with him. Despite a by no means smooth passage across the Pentland Firth, his energy and enthusiasm were such that by the evening of his arrival two instruments had been set up and were in operation.

Work also has been done and will again be done on ozone. An ozone spectrograph was in use in 1926–27, while a much improved instrument designed by Dr. G. M. B. Dobson, an ozone photo-electric spectrophotometer, was operated from 1940 to 1943.

Finally, a smoke pollution apparatus is maintained for the Director of Fuel Research. It need hardly be said that the intention here is to get measurements of relatively uncontaminated air. In the two years in which this record has been available less pollution has been recorded at the Observatory than at any other reporting station in Great Britain.

Life at the observatory.—Actual living conditions are greatly improved from what they were originally. Then lighting was by oil lamps, while water

was pumped from a nearby loch by wind pump, which was liable to give trouble. The domestic arrangements in the houses were "austere". The present water supply comes from Lerwick Waterworks, while all lighting is by electricity.

As elsewhere, living accommodation is a great difficulty, but a limited number of married quarters are available at the Observatory, and some of the houses are run as a hostel for the single staff.

To anyone interested in ornithology or in the "gentle art" of fishing, Shetland can be fascinating. It has loch and sea trout in large numbers, and a great variety of sea birds and waders. The island of Noss, a few miles beyond Lerwick, is maintained as a bird sanctuary, its nesting cliffs rising a sheer 592 ft. from the sea.

The length of day at midsummer is $18\frac{3}{4}$ hr., so that it is quite light throughout the night. The midwinter day is $5\frac{1}{2}$ hr. and the sun's altitude at noon $6\frac{3}{4}°$ as compared with $16\frac{1}{2}°$ for the extreme south of England. A cloudy winter day in Shetland therefore affords very poor light. The wind averages over 20 m.p.h. in winter as compared with 8 m.p.h. at Kew. It sometimes averages 30 m.p.h. in a month and may blow at over gale force with scarcely a let-up for days on end. Some people find these winter conditions of wind and poor daylight trying.

The climate however is comparatively mild, and it is difficult to realize that Shetland lies as far north as Cape Farewell in Greenland. Yet it is its magnetic latitude and its position close to the track of many Atlantic depressions, that make the geophysical and meteorological records of the Observatory of such value.

REFERENCES

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VARIATION OF UPPER AIR TEMPERATURE WITH SEASON AND LATITUDE

The collection and summarizing of upper air data by the Upper Air Climatology Section of the Meteorological Office for the preparation of charts of average temperature at different levels over the world has brought to light some interesting facts. A brief note of some of them may be of value in advance of the main publication.

Of the ten stations referred to in this note, seven are under the direct control of the British Meteorological Office; of the remaining three, Langenhagen in the British zone of Germany and Nairobi in British East Africa both use British instruments and send their data to the section dealing with upper air climatology at Harrow. The information for Jan Mayen is from data made available to the Meteorological Office by the courtesy of Dr. Sverre Petterssen and the Royal Norwegian Air Force. Particulars of the co-ordinates of the stations, periods, etc., are given in Table I.

TABLE I—UPPER AIR STATIONS CONTRIBUTING DATA

Station	Lat.	Long.	Period	Number of observations: January 700 mb.	January 100 mb.	July 700 mb.	July 100 mb.	Times of observation
								G.M.T.
Jan Mayen	71°01′N.	8°26′W.	July 1944–July 1945	62	40	123	81	1100, 2300
Lerwick	60°08′N.	1°11′W.	July 1945–Jan. 1950	618	382	620	401	0000, 0600, 1200, 1800
Langenhagen	52°28′N.	9°42′E.	July 1947–July 1949	186	61	247	178	0200, 0800, 1400, 2000
Larkhill	51°11′N.	1°48′W.	July 1945–July 1949	496	272	620	419	0000, 0600, 1200, 1800
Gibraltar (North Front)	36°09′N.	5°21′W.	July 1946–July 1949*	195	67	243	140	0430, 1500
Malta (Qrendi)	35°50′N.	14°27′E.	July 1946–July 1949	149	85	182	151	0200, 1500
Habbaniya	33°22′N.	43°34′E.	July 1946–July 1949†	284	81	322	114	1700 mainly
Bahrein	26°14′N.	50°35′E.	July 1947–July 1949	62	48	88	67	1500 mainly
Aden	12°50′N.	45°01′E.	July 1948–Jan. 1950	69	55	42	31	1400 mainly
Nairobi	1°17′S.	36°50′E.	June 1947–Dec. 1949	50	34	84	77	0600

*Also 1945–46 at 0800 and 1700 for 700 and 500 mb. †1943–49 at 700 and 500 mb.

TABLE II—AVERAGE TEMPERATURE OF STANDARD ISOBARIC SURFACES AND THE RANGE WITHIN WHICH 95 PER CENT. OF THE OBSERVATIONS LIE

	Average Jan.	Average July	95 per cent. range Jan.	95 per cent. range July	Average Jan.	Average July	95 per cent. range Jan.	95 per cent. range July
mb.	°A.	°A.	°A.	°A.	°A.	°A.	°A.	°A.
	JAN MAYEN				LERWICK			
100	204	230	11	9	215	227	18	12
150	208	229	13	11	217	226	22	15
200	210	227	21	17	216	225	23	20
300	214	228	14	14	222	230	15	13
500	235	253	20	16	245	256	19	14
700	251	267	22	16	262	272	15	12
	LANGENHAGEN				LARKHILL			
100	218	223	15	17	216	221	19	13
150	218	223	20	20	217	222	21	17
200	217	223	20	19	215	221	22	18
300	224	232	12	14	225	233	13	13
500	248	259	17	13	249	259	20	13
700	264	274	18	14	265	274	18	14
	GIBRALTAR				MALTA			
100	213	209	20	11	213	208	12	13
150	215	213	26	13	216	215	18	13
200	216	221	19	13	217	224	21	12
300	228	237	12	10	227	238	9	13
500	253	263	17	9	253	264	14	10
700	270	284	19	7	269	281	15	11
	HABBANIYA				BAHREIN			
100	210	202	14	15	204	199	13	13
150	215	214	13	16	212	213	15	15
200	218	227	18	14	220	227	15	14
300	227	247	11	11	233	248	16	12
500	253	270	12	12	258	269	14	13
700	269	287	12	9	275	290	13	7
	ADEN				NAIROBI			
100	195	196	11	(13)	196	200	(10)	13
150	207	207	8	(11)	208	208	14	13
200	220	221	8	9	221	219	10	9
300	241	243	7	7	242	241	6	8
500	267	267	5	7	267	267	6	6
700	283	289	6	5	283	281	6	7

Figures in brackets indicate less than 40 observations.

Table II gives the average temperature in January and July of the isobaric surfaces of 700, 500, 300, 200, 150 and 100 mb. together with the ranges within which 95 per cent. of the individual observations lie. The averages are plotted in Fig. 1.

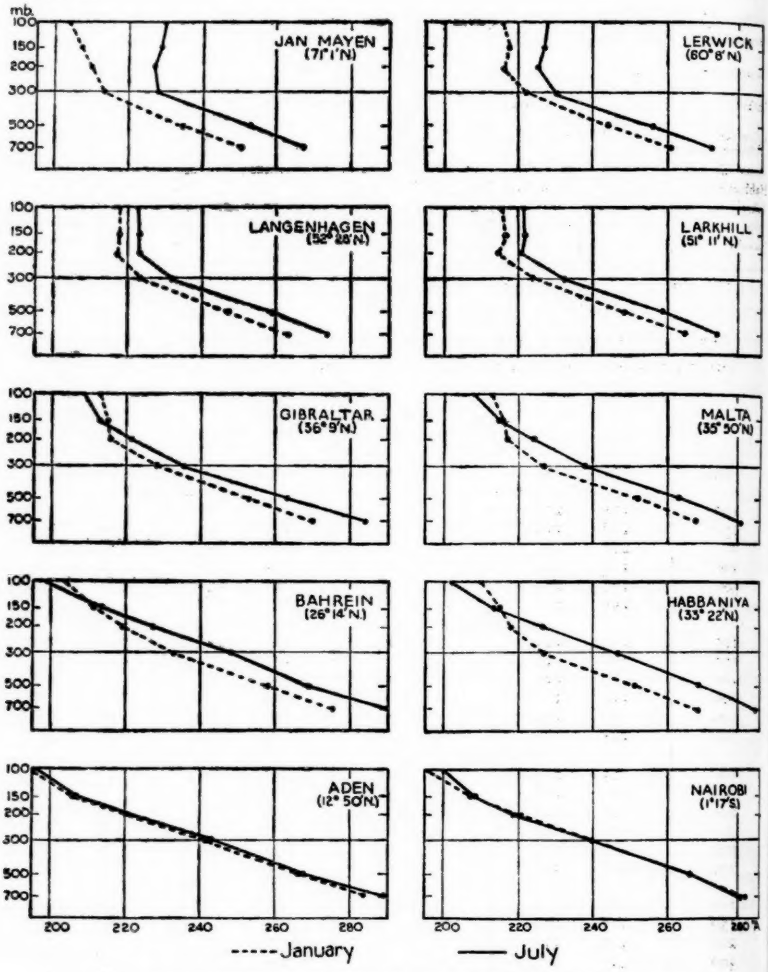


FIG. 1—VARIATION OF AVERAGE TEMPERATURE WITH HEIGHT

The most striking feature is the seasonal variation of temperature in the stratosphere. In the far north at Jan Mayen the average difference of temperature between January and July becomes greater with increasing height —at 300 mb. it is 14°A., at 100 mb. 26°A. The increase appears to be due to the continued falling off of temperature above 300 mb. in January whereas in July the stratosphere is nearly isothermal. A similar increase is shown in the war-time ascents at Vadsø in north Norway where the range is 15°A. at 300 mb. and 24°A.

at 96 mb., but there it is associated with an increase of stratospheric temperature with height in July rather than with a decrease in January. A similar though less well marked increase is shown in the diagram for Lerwick, some 10° farther south, but not at Larkhill or Langenhagen where the range in the stratosphere is less than in the troposphere.

South of about latitude 40°N. the seasonal variation of temperature in the stratosphere is the reverse of that at the surface, July showing lower temperatures than January; 4° or 5°A. lower at Malta and Gibraltar and 8°A. at Habbaniya. This change in regime is associated with a well marked seasonal variation in the height of the tropopause, January tropopauses being appreciably lower than those in July.* Farther south, in equatorial regions, the seasonal range in the temperature of the stratosphere is small, and such evidence as there is indicates that January is slightly cooler than July.

Approximate values of the range of temperature within which 95 per cent. of the observations lie are also given in Table II. There is a good deal of irregularity in the values, part of which may be due to uncertainty in making the estimates, but the most marked feature is the much greater range, particularly in the higher latitudes, at 200 mb. than at 300 mb. At stations north of 30°N. in both seasons, 200 mb. is the level at which the range is greatest, except at Gibraltar in January where the maximum is at 150 mb.—this is much less conspicuous if the 80 per cent. range is used rather than the 95 per cent.

The change of temperature with latitude along isobaric surfaces in the troposphere shows the expected decrease with increase of latitude, greater in winter than in summer. The large difference between Malta and Habbaniya in July is a reminder, however, that latitude is not by any means the only factor of importance.

The change of temperature with latitude at higher levels is of great interest. At 200 mb. the extreme range in both months is only about 10°A., from 210° to 221°A. in January and from 219° to 227°A. (in the reverse direction) in July. That the level at which the day-to-day variations are greatest should be the same as that at which the variation with latitude is least is remarkable. It suggests that the large day-to-day changes are due to vertical rather than to longitudinal motion—but it must be remembered that longitudinal motion does not necessarily take place along an isobaric surface.

At 150 and 100 mb. average temperature is fairly uniform in January between 40°N. and 60°N. but decreases thence both towards the pole and the equator, the latter being the region of greater cold. In July on the other hand temperature falls southwards from 70°N. to about 10°N. the rate of fall being greatest in middle latitudes. In July, Aden is appreciably colder than Nairobi at 100 mb.

These results refer to stations in Europe, the Middle East and Africa; a comparison with similar data for the American continent would be of considerable interest.

Frequencies of tropopause pressures.—Table III gives the frequency, expressed as a percentage, with which pressure at the tropopause lies within successive 20-mb. ranges. The column 420 refers to the 20-mb. range 410–429mb.

*After this note was written, average temperatures for stations in New Zealand between 29°S. and 45°S. were received from the Director of the New Zealand Meteorological Service. They show similar characteristics, i.e. lower stratospheric temperatures and higher tropopause in summer (January) than in winter (July).

TABLE III—PERCENTAGE FREQUENCIES

	≥430	420	400	380	360	340	320	300	280	260	240
				millibars							
				percentage frequency							
RADIO-SONDE STATIONS											
Lerwick											
Dec.—Feb.	1	1	2	3	2	3	4	10	11	11	13
June—Aug.	...	...	<0·5	<0·5	1	2	4	7	11	17	18
Larkhill											
Jan.	<0·5	<0·5	1	2	2	3	3	6	7	12	12
July	<0·5	...	...	<0·5	1	1	1	4	5	10	15
Gibraltar											
Dec.—Feb.	...	<0·5	<0·5	1	1	1	1	5	5	10	15
June—Aug.	...	...	...	...	...	...	...	...	1	1	2
Malta											
Dec.—Feb.	...	<0·5	<0·5	1	<0·5	2	4	3	6	13	16
June—Aug.	...	...	...	...	...	...	<0·5	<0·5	1	2	5
Nicosia											
Dec.—Feb.	<0·5	<0·5	1	2	3	1	4	6	11	11	18
June—Aug.	...	...	...	...	...	...	1	...	1	1	3
Habbaniya											
Dec.—Feb.	...	...	...	...	1	...	1	4	5	8	14
June—Aug.	...	...	...	...	...	...	...	...	<0·5	...	...
Benina											
Dec.—Feb.	...	...	1	1	2	1	3	1	4	11	15
June—Aug.	...	...	...	...	...	...	...	1	1	4	3
Bahrein											
Dec.—Feb.	...	...	...	...	...	...	...	...	...	...	...
June—Aug.	...	...	...	...	...	...	...	...	...	...	...
Aden											
Dec.—Feb.	...	...	...	...	...	...	...	...	...	...	...
June—Aug.	...	...	...	...	...	...	...	...	...	...	...
Nairobi											
Dec.—Feb.	...	...	...	...	...	...	...	...	...	...	...
June—Aug.	...	...	...	...	...	...	...	...	...	...	...
BALLON-SONDE STATIONS											
England											
Dec.—Feb.	...	1	1	...	2	4	4	8	3	9	22
June—Aug.	...	...	...	...	...	1	4	4	9	8	16
Agra											
Dec.—Feb.	...	...	...	...	...	...	...	...	...	...	1
June—Aug.	...	...	...	...	...	...	...	...	...	...	...
India N. of 20°N.											
Dec.—Feb.	...	...	...	...	...	...	...	...	...	...	2
June—Aug.	...	...	...	...	...	...	...	...	...	...	...
India S. of 20°N.											
Dec.—Feb.	...	...	...	...	...	...	...	...	...	...	...
June—Aug.	...	...	...	...	...	...	...	...	...	...	...

and so on. Values are given for two seasons, December–February and June-August, except at Larkhill where January and July only have been used. The upper part of the table refers to data from radio-sondes and the lower part to ballons-sondes. All the data are from manuscript records in the Meteorological Office, except those for India which were extracted from *Upper Air Data* published by the India Meteorological Department. The frequencies from the radio-sonde observations are plotted in Fig. 2 and from the ballons-sondes in Fig. 3.

In winter the marked difference in the character of the diagrams for stations north and south of 30°N. is very striking. There is, however, some indication that even in that season the tropical regime sometimes penetrates as far north as Habbaniya and may even reach the Mediterranean. The comparatively large number of low tropopauses at Nicosia may be associated with the Cyprus " low ", characteristic of the winter months.

OF TROPOPAUSE PRESSURES

	220	200	180	160	140	120	100	80	60	40	No. of obs.
	millibars										
	percentage frequency										
RADIO-SONDE STATIONS											
Lerwick											
Dec.—Feb.	14	13	9	3	<0·5	...	...	...	...	...	351
June—Aug.	20	15	4	1	...	...	...	...	...	...	418
Larkhill											
Jan.	19	18	12	2	1	...	...	...	...	...	476
July	28	21	10	3	1	...	...	...	...	...	580
Gibraltar											
Dec.—Feb.	13	25	16	5	1	<0·5	1	...	...	...	301
June—Aug.	4	12	18	16	18	16	11	1	<0·5	...	366
Malta											
Dec.—Feb.	19	19	11	4	1	1	<0·5	...	...	...	446
June—Aug.	6	11	7	9	14	21	19	5	...	...	422
Nicosia											
Dec.—Feb.	15	16	7	1	1	1	1	1	...	...	324
June—Aug.	4	6	4	2	9	21	36	11	1	...	157
Habbaniya											
Dec.—Feb.	19	20	9	5	2	3	7	2	...	...	425
June—Aug.	...	<0·5	1	<0·5	<0·5	6	32	45	13	1	247
Benina											
Dec.—Feb.	22	20	11	5	3	<0·5	...	<0·5	...	...	322
June—Aug.	...	2	4	4	3	12	44	20	2	...	127
Bahrein											
Dec.—Feb.	...	...	1	2	5	7	39	38	8	...	146
June—Aug.	...	...	...	...	...	4	20	55	19	2	84
Aden											
Dec.—Feb.	...	...	...	...	2	12	40	44	2	...	127
June—Aug.	...	...	...	...	...	9	55	36	...	...	90
Nairobi											
Dec.—Feb.	...	...	...	...	1	9	29	47	14	...	101
June—Aug.	...	...	...	...	4	13	55	24	4	...	114
BALLON-SONDE STATIONS											
England											
Dec.—Feb.	17	16	12	1	...	...	...	...	...	...	139
June—Aug.	21	28	7	1	1	...	...	...	...	...	134
Agra											
Dec.—Feb.	1	3	1	3	5	20	42	23	1	...	151
June—Aug.	...	...	...	1	1	18	61	19	...	...	102
India N. of 20°N.											
Dec.—Feb.	...	...	...	2	7	20	49	18	2	...	55
June—Aug.	...	...	...	...	4	26	56	14	...	...	97
India S. of 20°N.											
Dec.—Feb.	...	...	1	6	12	34	32	14	1	...	132
June—Aug.	...	...	...	...	5	49	35	10	1	...	74

In summer the contrast is less well marked; high tropopauses, with pressure as low as 100 mb., are found not infrequently even in the western Mediterranean and are more frequent than any other type in the eastern (Nicosia). Occasionally, however, the lower tropopauses of middle latitudes are found as far south as 30°N., though from the Mediterranean southwards the tropopause in summer rarely falls below the 300-mb. level.

It is of some interest that at both Nairobi and Aden the frequency of very high tropopauses (pressure less than 90 mb.) is greater from December to February than from June to August.

In June–August the tropopause at Bahrein is usually at a higher level than at Aden or Nairobi; on 76 per cent. of occasions the tropopause pressure is less than 90 mb. compared with 36 per cent. and 28 per cent. respectively at the other two stations.

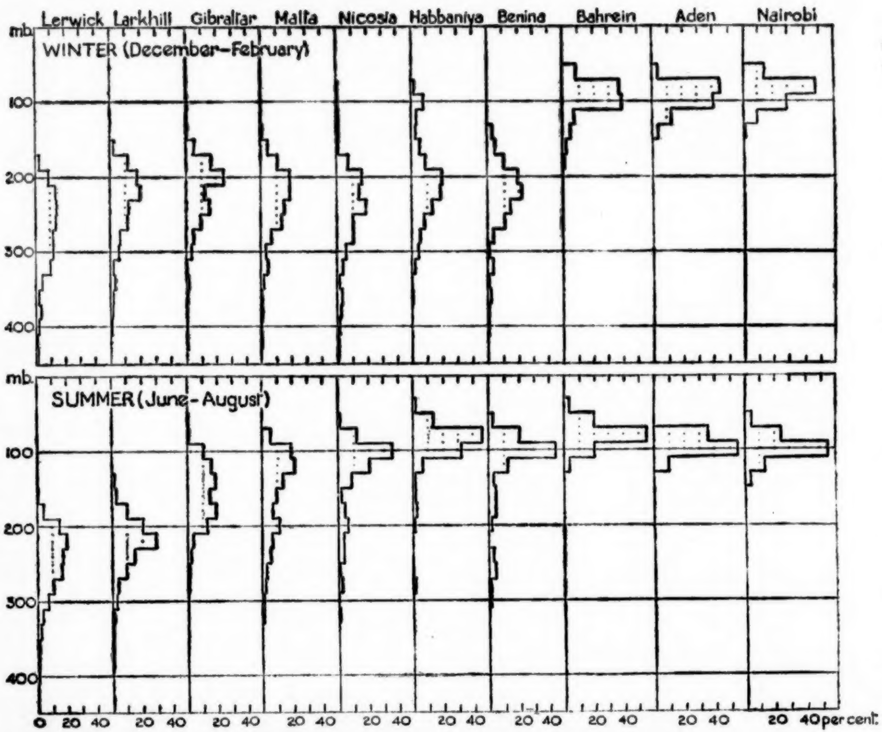


FIG. 2—FREQUENCIES OF TROPOPAUSE PRESSURES

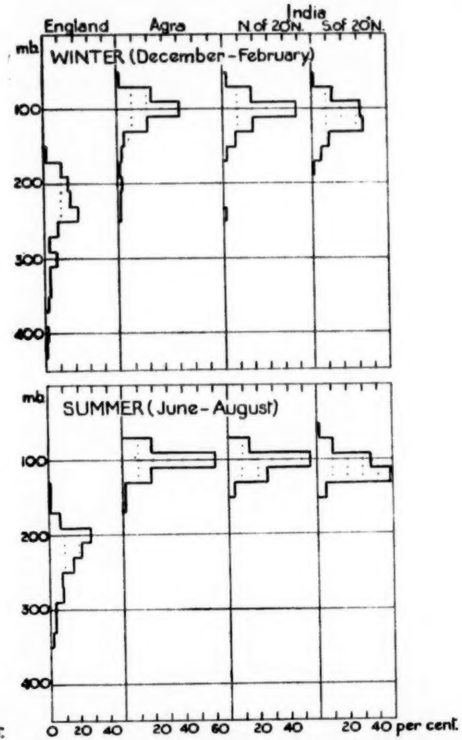


FIG. 3—FREQUENCIES OF TROPOPAUSE PRESSURES OVER ENGLAND AND INDIA

For comparison with the radio-sonde data, frequencies from ballon-sonde data are given for England and for India. Those for England are from ascents made at Benson, Kew and Sealand (lat. 51°–53°N.). Those for India are in three groups: one for Agra, and two others for stations north and south respectively of 20°N. During the monsoon lower tropopauses are more frequent at the more southerly stations than in the north.

Ballons-sondes at Batavia reached the tropopause on too few occasions to give reliable values, but in the majority of the observations the pressure was between 70 and 110 mb.

LEGACY OF THE ICE-AGE

By C. E. P. BROOKS, D.Sc.

The surface of the globe, and its inhabitants including man, were largely re-made by the great climatic crises of the past million years known as the Pleistocene, or the Quaternary ice age, and there is good reason to suppose that the sequence of glaciation and deglaciation has not yet come to an end. That being so, the study of this period is of very great human interest, but it is also one of great difficulty. Changes of climate on a large scale followed one another with—geologically speaking—bewildering rapidity, and as the continents and oceans had almost reached their present configuration, the traces of the various climatic episodes have hitherto been found only in terrestrial deposits, and tend to be local and disconnected. The evidence is abundant but highly various—glacial moraines, river terraces, wind-blown sands, the former and existing distribution of animals and plants, human archæology, soil structure—in fact almost everything in nature has some bearing on climatic history. One of the difficulties of research is that no one man can master all these subjects, and experts have tended to work independently in their own water-tight compartments, reaching conclusions which are not always compatible with those of others. There has been plenty of individual research; the urgent need now is for collaboration between workers in different sciences to produce a world history of climatic, geographical and biological changes which fits all the evidence and is also physically sound.

In June 1947 the Division of Geology and Geography of the National Research Council in the U.S.A. set up a " Committee on Interrelations of Pleistocene Research," as a start " toward creating lateral communication through these invisible bulkheads that interfere with research progress." The first report of this Committee has now been published by the Geological Society of America under the title " Pleistocene Research "*. It consists of an Introduction by R. F. Flint and eleven contributions by members of the Committee, of which the report on " Biogeography in the Pleistocene," by Edward S. Deevey, Jr., is by far the longest, occupying 102 pages. Deevey's contribution raises some highly interesting problems; for example, south-west Ireland possesses a number of species which require warm winters and yet, to all appearances, contrived to live through glaciation within a few miles of an ice-sheet. In the past these anomalous distributions have often been accounted for by the light-hearted creation of " land bridges," sometimes across wide expanses of ocean, but this easy way out finds no favour with Deevey. It may

*Committee of Interrelations of Pleistocene Research. Pleistocene Research. *Bull. Geol. Soc. Amer., Rochester N.Y.*, **60**, 1949, p. 1303.

be added that his report includes several very useful tables embodying the latest conclusions about glacial and post-glacial succession and correlation. He remarks that the climate of the three interglacial periods " progressed from cold to as warm as to-day and back to cold again, while the middle one seems to have been the warmest as well as the longest." Other contributions, though shorter, also contain much material of interest to climatologists.

Each report surveys the existing position from the standpoint of the author's own subject; so far they are still disconnected essays and no doubt the next task of the Committee will be to study and collate them. But two points have already emerged: the first is that, in the face of the great difficulty of correlating the deposits in different parts of the world by ordinary geological methods, the most helpful line of correlation is climatic. From earlier geological periods marine sediments greatly predominate, and, with few exceptions, it is possible to assume that two marine deposits which contain the same index fossils are of the same age. That is because ocean temperatures over the world were more uniform than during the Pleistocene, and changed slowly enough for evolution more than to keep pace with them. In the Pleistocene on the other hand the range of climate was much greater, and the changes were so rapid that the only way for most plants and animals to survive was by migration. Hence if two deposits, widely separated in latitude, contain the same assemblage of plants and animals (single species are untrustworthy) the inference is that they are of different ages. Human artefacts are particularly difficult in this respect. On the other hand, the general sequence of climatic events appears to have been closely similar all over the world. The two best known sequences, those of northern Europe and North America, agree so closely that the general correlation is no longer in doubt. Other parts of the world are not so well known, especially with regard to the earlier stages of the ice-age, and there is still some uncertainty. The main difficulty however is in the correlation of events in the glaciated and non-glaciated regions, and here an improved knowledge of world climatology during the Pleistocene would be helpful.

The second point, which is brought out by Fred B. Phleger in a short note on " Submarine geology and Pleistocene research," is that the study of the deep ocean beds now proceeding by means of long cores cut out from the deposits in the depths of the oceans, promises to provide a sequence of changes of sea temperature, free from the breaks and ambiguities which are inevitable in terrestrial deposits, which can be used as a world-wide standard of comparison. The remarkable results already achieved will be familiar to meteorologists from a recent article by C. D. Ovey*.

The general subject of " Climatology of the Pleistocene " is briefly discussed by Helmut Landsberg, who points out the difficulties of the astronomical chronology of the ice-age and the unsatisfactory nature of all " theories " as to the cause of glaciation. Surface data are not enough; we must somehow reconstruct the upper air circulation at various stages of the Pleistocene; the distribution of ash-layers from volcanic eruptions may possibly help here. At present even the circulation above an ice-cap is not fully known. The future contribution of meteorology to the problem of climatic change lies in the close analysis of trends in instrumental observations, and possibly in laboratory

*OVEY, C. D.; Note on the evidence for climatic changes from sub-oceanic cores. *Weather, London*, **4**, 1949, p. 228.

experiments with models. Landsberg remarks that " the production of an ' ice-cap ' in the laboratory might lend considerable weight to any of the thermodynamic hypotheses proposed."

" Theories " are perhaps rather outside the present scope of the Committee, which is concerned more with the collection and correlation of a wide variety of facts. That may be the reason for the omission from the list of contributors of a solar physicist, but a report on modern views as to possible variations of radiation from the sun, both in quantity and wave-length, would have been of great interest. The part played by solar radiation in climatic changes is still very obscure, first because of the divergent views as to whether the sun is a variable star or not, and secondly because, supposing that variations do occur in either the total radiation or its distribution among wave-lengths, the effect on terrestrial climate is not known. On the one hand we have Sir George Simpson's well known dictum that glaciation can only be accounted for by increased solar radiation, and on the other hand we have the view of many geologists and biologists that the periods of glaciation were accompanied by a world-wide lowering of temperature. The contradiction is often met by the rather vague assertion that an increase of ultra-violet radiation may have changed the pressure distribution at the surface by changing the amount of ozone in the stratosphere, without affecting mean surface temperature. So far as I am aware, however, no one has so far attempted to follow out this idea quantitatively, and, until the solar basis is firmer, it would appear to be a waste of time to try.

Another contribution of interest to climatologists is by H. T. U. Smith: " Physical effects of Pleistocene climatic changes in nonglaciated areas: eolian phenomena, frost action, and stream terracing ". The interpretation of fossil dunes in terms of wind direction is of importance for the study of the circulation of the atmosphere near ice-sheets, and the study of frost action is also of great interest; this report includes an extensive bibliography.

It is obvious that data on the Pleistocene are superabundant, and the Committee has made a fine start in summarizing them and pointing out the difficulties of interpretation. This is a necessary beginning to overcoming these difficulties, and all scientists whose material reflects the past will look forward with interest and expectation to the next report.

METEOROLOGICAL RESEARCH COMMITTEE

The ninth meeting of the Instruments Sub-Committee was held on October 5, 1950. Most of the time of the meeting was spent in considering various aspects of the measurement of meteorological quantities in the upper air. The evidence for a real diurnal variation of temperature in the lower stratosphere was discussed. On the whole it seems probable that the apparent diurnal variation as indicated by radio-sonde measurements cannot all be attributed to radiation errors of the measuring instrument.

The design of future elements (temperature, pressure and humidity) for radio-sondes was discussed and certain lines of investigation decided on, which, it is hoped, will indicate the best way in which to change existing designs.

Further consideration was also given to the use of searchlights for determining the density of the atmosphere at great heights.

The Physical Sub-Committee held its 12th meeting on October 19, 1950. A proposal for laboratory investigation of convection was considered and supported. Some time was also given to a consideration of the mathematical treatment of turbulence based upon observations of temperature gradient in the lowest layers of the atmosphere.

A paper[1] by C. S. Durst and N. E. Davis on the accuracy of geostrophic trajectories was also considered.

[1]*Met. Res. Pap., London*, No. 574, 1950.

OFFICIAL PUBLICATION

The following publication has recently been issued :—

British Rainfall 1948

This volume, which is published by H.M. Stationery Office at £1 1s. od., retains the essential features of earlier volumes. It provides a comprehensive summary of the rainfall of 1948 over Great Britain and Northern Ireland, both as regards its incidence during the year and its variation from place to place.

The book is arranged in three parts. Part I consists of eleven chapters dealing with such matters as the distribution of monthly, seasonal and annual rainfall, periods of drought and of wet spells, duration and intensity of rainfall, notably heavy daily falls, evaporation and percolation. The articles are illustrated by numerous maps and a coloured plate showing the relation of rainfall in 1948 to the average. The publication of so much information is made possible by the co-operation of a large body of voluntary observers, who measure the rainfall primarily as a matter of personal interest, and by public authorities—especially the authorities of water undertakings—who find that a knowledge of rainfallis essential to them in their work. Reference is made to the deaths of 61 observers. Of these 23 had kept rainfall records for upwards of 30 years and two for no less than 60 years.

Part II is the General Table of Rainfall and gives the recorded total fall with the number of rain-days and wet-days at about 5,000 stations, together with the names of the observers or other authorities.

Part III contains an article in which Mr. L. C. W. Bonacina surveys the snowfall in the British Isles during the years 1936–45. On the whole this decade was a decidedly snowy one, but the seasonal incidence of snowfall was more normal than in several previous decades, showing a tendency for maximum depth in winter rather than in early spring.

UNITED STATES TECHNICAL CONFERENCE ON AIR POLLUTION

The increasing interest of America in atmospheric pollution was clearly shown by the attendance at the above conference, which was called at the request of President Truman. Over 700 engineers, physicists, meteorologists, biologists and legal experts gathered at one of Washington's big hotels to read papers and listen to discussions on this subject. The British delegation consisted of Dr. Parker, the Director of the Fuel Research Station, Greenwich; Mr. Damon, Chief Alkali Inspector of the Ministry of Health; and Prof. O. G. Sutton, Chairman of the Atmospheric Pollution Research Committee (D.S.I.R.). The Conference (held in May 1950) formed itself into a number of Panels, that of meteorology being under the chairmanship of

Dr. E. W. Hewson, who is, of course, well known in this country, assisted by Dr. Wexler of the U.S. Weather Bureau and Dr. Lansberg.

In his opening address Dr. Hewson gave a summary of what has been done so far in the study of the diffusion of suspended matter. The problem falls into two parts: (i) that of the isolated source, such as a factory chimney, and (ii) that of the dispersion of pollution from an area source, such as a city. Mathematicians, not unnaturally, have tended to concentrate on the first of these problems, and Dr. Hewson spent some time in discussing the formulæ for the concentration at ground level from a single continuous elevated source proposed by Bosanquet and Pearson, and by Sutton, and Lowry. The position seems to be that in overcast windy weather, when the lapse rate is small, all the formulæ provide reasonably accurate predictions, but for large temperature gradients, and particularly for inversions, much remains to be done. In the second problem the classical work is that of Dr. Meetham at Leicester. This, of necessity, tends to be more statistical in its approach.

Dr. Hewson was followed by Mr. K. L. Calder, formerly of the Meteorological Office and now in charge of Meteorology at the Army Chemical Corps Station at Camp Detrick, Maryland, who reviewed briefly the theoretical basis of work done at Porton, namely the derivation of the diffusion coefficient from measurements of the transfer of momentum, as indicated by the velocity profile near the ground. He also gave some very simple theoretical and semi-empirical expressions for concentrations from line and point sources which are probably sufficiently accurate for atmospheric pollution studies.

Prof. Sutton read a paper on the mathematical analysis of the ascent of a jet of hot air in a calm atmosphere, and showed how his formula agreed with the laboratory observations of Schmidt. He also gave an approximate treatment of the same jet in a horizontal side wind, and showed that in these circumstances the reduction in ground concentration caused by adding heat to an elevated source of pollution is directly proportional to the amount of heat put in and inversely proportional to the height of the chimney and the cube of the speed of the side wind.

Mr. Ward F. Davidson dealt with the problem of the design of power stations so as to minimize the effects of pollution in the vicinity of the plant. A specially designed low-speed wind tunnel has been used to investigate the effect of the ratio, (stack height) / (building height), on the stream-lines of the air flow to the lee. In the particular case discussed, reducing the height of the building upwind of the stack increased the concentration of smoke at ground level, a result which was not expected.

Dr. Hans Neuberger of Pennsylvania State College dealt at some length with the relations between concentration of condensation nuclei, the duration and transparency of fogs and the size and number of droplets in a fog. This is an extremely complicated problem and it was evident that, despite the excellent work described, much remains to be done.

Dr. P. E. Church gave an account of the microclimatological installation at the University of Washington. This is mainly concerned with an accurate evaluation of the terms in the heat-balance equation, and therefore with fundamental work so badly needed in this subject.

Dr. J. Z. Holland (U.S. Weather Bureau), who is stationed at Oak Ridge, Tennessee, dealt with the formidable problem of diffusion in hilly country, by adopting the familiar " rough surface " theory of aerodynamics to this case.

The formal session concluded with a most interesting film, shown by Mr. M. E. Smith, of the Brookhaven National Laboratory. This consisted of " lapse-time " records of smoke trails from the mast at Brookhaven. In the early morning the plume is solid in appearance for many miles downwind, illustrating the stabilizing effects of a large inversion. As the sun rises higher in the sky and the inversion gives place to a lapse, the plume first wavers and then breaks up in a most striking fashion. No one, after seeing this film, could doubt that meteorological factors must play a dominant part in determining the intensity of smoke concentration downwind of an industrial plant.

The general impression left on the writer is that America is taking micro-meteorology very seriously, not only in relation to atmospheric pollution but in its impact on agriculture and on life generally. So far little that is new or revolutionary has emerged, but it should be remembered that, as yet, the subject is in its infancy in the United States. When the initial phase is over, we may look for some exciting results, if the enthusiasm displayed at Washington is any criterion.

O. G. SUTTON

LETTERS TO THE EDITOR

Low humidity

In the past, several references have been made to instances of abnormally dry air over the British Isles. E. G. Bilham in his book[1] quotes readings of 15 per cent. relative humidity at Cardington on April 1, 1931, and at South Farnborough on July 10, 1934. Since then R. S. Read[2] has added White Waltham (April 15, 1942) to this list and at that time it appeared that 15 per cent. might be the lowest humidity recorded in Britain. Later, A. J. Drummond[3] reported two occasions from Kew Observatory records when humidity was less than 15 per cent.:—

1800 G.M.T., June 3, 1939: 13 per cent.
1515 G.M.T., April 15, 1942: 10 per cent.

E. L. Hawke, in a more recent note[4] draws attention to observations made many years ago by R. H. Barnes of Parkstone, Dorset; there were three days when humidity was less than 15 per cent.:—

	Date	Dry bulb	Wet bulb	Vapour pressure	Dew point	Relative humidity
G.M.T.		°F.	°F.	mb.	°F.	%
1700	April 2, 1892	66·7	47·3	2·5	11	11
1530	May 23, 1901	69·3	49·1	3·2	14	11·5
1600	May 24, 1901	71·6	49·9	2·6	12	9·5

Hawke points out that there may be other instances of very low humidity which have passed unrecorded.

From Meteorological Office stations overseas, J. Durward[5] has referred to an observation made at Heliopolis at 1200 G.M.T. on June 13, 1933, when the dry- and wet-bulb readings were 117·2°F. and 69·2°F., vapour pressure, 3·1 mb., dew point 16°F. and relative humidity 3 per cent. Only recently, Senior Meteorological Officer, No. 1 Meteorological Unit, M.E.A.F., forwarded

the following interesting letter on low humidity at Shallufa in the Suez Canal zone (30°03′N., 32°33′E., height 49 ft.)

"At 1300 G.M.T. on April 1, 1950, dry-and wet-bulb readings were 86·2°F. and 55°F. respectively. Using 'Hygrometric Tables'[6] the vapour pressure can be evaluated as 0·9 mb. and the relative humidity as 2 per cent. These tables do not extend sufficiently far to enable the dew point to be determined; it is below 0°F. Using the Bilham slide-rule (tropics), the vapour pressure can be evaluated by extrapolating just beyond the end of the linear vapour-pressure scale and the relative humidity can be estimated by extrapolation on the non-linear scale. Similar values to those obtained from the 'Hygrometric Tables' are given. The dew point cannot be determined from the slide."

Reference to Linke's "Meteorologisches Taschenbuch IV"[7] and the Goff-Gratch Tables 1946 (I.M.O. Resolution 164, Washington 1947) shows that the dew point on this occasion was −10°F.!

Readers will no doubt be interested to learn of other occasions of abnormally dry air; observers at home and overseas are therefore invited to forward details to the Editor and to include a note on the surface wind obtaining at the time and on the synoptic situation leading up to the occurrence in addition to the usual instrumental data.

G. NEEDHAM

May 5, 1950

1. BILHAM, E. G.; The climate of the British Isles. London, 1938, p. 226.
2. READ, R. S.; Exceptionally dry air. *Quart. J. R. met. Soc., London*, **68**, 1942, p. 294.
3. DRUMMOND, A. J.; Abnormally dry air at Kew Observatory. *Quart, J, R, met, Soc., London*, **68**, 1942, p. 292.
4. HAWKE, E. L.; The incidence of extremely low humidity in southern England. *Quart. J. R. met. Soc., London*, **70**, 1944, p. 274.
5. DURWARD, J.; Behaviour of the hair hygrograph at Heliopolis. *Met. Mag., London*, **68**, 1933, p. 137.
6. London, Meteorological Office. Hygrometric Tables. London, 4th edn., 1940.
7. LINKE, F.; Meteorologisches Taschenbuch IV. Leipzig, 1939.

Pilot balloon ascent near cumulonimbus cloud

During the afternoon of July 27, 1940, the writer, while at Wattisham (10 miles west-north-west of Ipswich, Suffolk), followed a "tail" balloon which appeared to enter air currents descending at several hundred feet per minute. At the time of the ascent a trough of low pressure lay over south-east England. From the data available in the *Daily Weather Report*, the general wind was northerly, increasing to about 15 kt. at 6,000 ft. Thunderstorms, with local hail, were occurring over the whole of England south-east of a line from The Wash to Portland Bill. From one of these, 2·48 in. of rain fell in 3¼ hr. at Waldringfield (7 miles east of Ipswich). The cloud which affected the ascent lay to the south of Wattisham, and light rain started about a quarter of an hour after the beginning of the observations and continued, light or moderate, till well after their completion. Thunder was heard from the cloud, but no lightning was observed.

Heights and positions of the balloon were computed in the usual manner at minute intervals. The positions are shown in Fig. 1, and the heights above the station in Fig. 2. These heights give the mean downward speed of the balloon from the 15th to the 18th minutes as about 700 ft./min., to which must be added the rate of rise of the balloon through the air (normally 500 ft./min.),

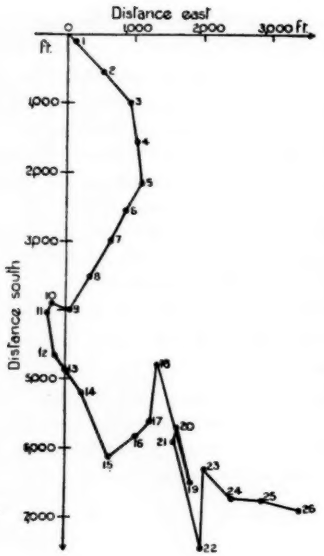


FIG. 1—PLAN OF POSITION OF BALLOON

Number by each position indicates time, in minutes, from release.

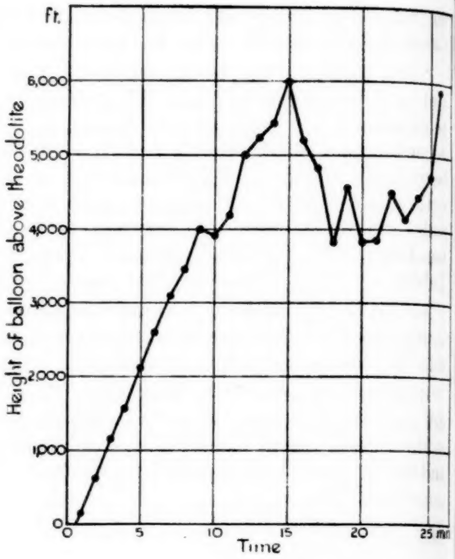


FIG. 2—HEIGHT OF BALLOON AT MINUTE INTERVALS

in order to obtain the speed of the air. But these figures must be considered in relation to possible errors.

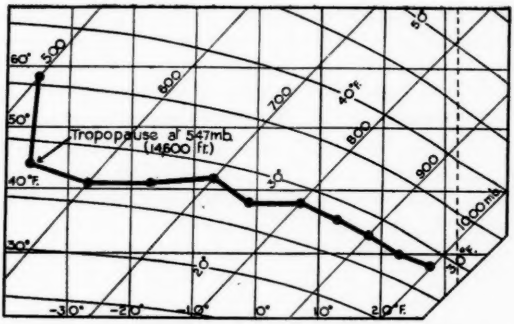
An inclination of the tail of 20° to the vertical would increase the calculated height by 360 ft. and the distance by 450 ft. at the maximum distance observed. The readings at the 19th and 22nd minutes were obviously affected in this way. The weight of precipitation resting on the balloon could force it down through the air, but had this occurred the tail would have gone completely away from the vertical, or above the balloon, and this did not happen. The mean motion over the last three minutes suggests that the apparent downward motion was not due to a leak. Thus there is little doubt that the balloon was affected by downward currents of up to about 500 ft./min. This is most probable during the 9th to 10th and 15th to 18th minutes, and possible at any point from the 18th to the 23rd minutes. The first two occasions appear to have been connected with anti-clockwise motions about 100 yd. and 300 yd. in diameter respectively.

R. H. ELDRIDGE

May 13, 1950

Unusually cold upper air temperatures for April

Extraordinarily cold tropospheric air was reported at Leuchars at 0200 G.M.T. on April 25, 1950, associated with the outbreak of very cold air over the British Isles at that time. It is thought that the temperature readings constitute a record for April.



TEPHIGRAM OF THE LEUCHRES ASCENT, 0200 G.M.T.
APRIL 25, 1950

Minimum values of the temperature for England for January and February at various heights have been listed by Miss F. M. Jones, who gives the extreme value of -21°C. (-6°F.) for the temperature at 3 Km. (about 9,850 ft.), whilst the Leuchars ascent shows a temperature of -7°F. at 8,970 ft. (700 mb.). Furthermore, Jones quotes the minimum of -38°C. (-36°F.) for 5 Km. (about 16,405 ft.), which may be compared with the Leuchars value of -35°F. at 14,460 ft. (550 mb.). This comparison of the Leuchars readings of April 25 with the winter extremes for England strongly suggests that the former must be a record or at least a near record for south-east Scotland during April.

R. MURRAY

[The tropopause was at about 14,600 ft. over Leuchars on this occasion, which is extremely low for the British Isles. Over Paris on February 20, 1948, it was at 13,500 ft.*, and, on the same day, the tropospheric air over south-east England was 6–8°F. colder than over Leuchars on April 25, 1950, below the 700-mb. level and warmer by about the same amount above the 700-mb. level.—Ed., *M.M.*]

NOTES AND NEWS

A Chronology of British weather

The late R. W. Jeffery, M.A., F.S.A., Fellow and Tutor of Brasenose, spent many years in compiling a chronology of British weather and embodied the results in two stout volumes of typescript. These volumes have been presented to the Meteorological Office Library by his relatives. Mr. Jeffery gave his work the title " Was it wet or fine? being an account of English weather from chronicles, diaries and registers ".

The ground covered is from Norman times to 1931, truly an immense field. The author usually begins with the Anglo-Saxon Chronicle as his earliest authority and he divides his work into nine chapters each devoted to a particular type of phenomenon. Chapter I, for example, deals with frost and snow, Chapter V with rain and floods, and so on. The records are woven into a kind

* DOUGLAS, C. K. M.; An unusual vertical temperature distribution over Brussels and Paris. *Met. Mag., London*, 77, 1948, p. 169.

of continuous narrative connected together here and there with other historical events to give continuity. It is a moot point whether this method of presentation is preferable in a work of reference to a plain straightforward chronology. The author to some extent disarms this criticism by providing in an appendix a chronological list of years with a brief note of the phenomena recorded in each.

The whole compilation shows immense industry and research. All the events are referred to an authority. Great use is made of the diaries of Pepys, Evelyn, John Wesley, and others for the 17th and 18th centuries, and of the newspapers for the 19th and 20th centuries. In fact the author obviously experiences the chief difficulty of the compiler who would write a complete record of British weather. Up to, say, 1600 A.D. the trouble is to make sure that everything known is included. After that date and especially from about 1750 onwards the difficulty is to decide what to omit. Mr. Jeffery's work is the only one known to me that endeavours to cover the whole historical record with any degree of completeness. It is not so exhaustive as *Geophysical Memoir* No. 70 in respect of the early years of the Christian Era but it is nevertheless a remarkable work of reference and will form an extremely useful addition to the Office Library.

C. E. BRITTON

Visit to the United Kingdom of the National Research Council of Canada De-icing Team

The National Research Council of Canada, in collaboration with the Royal Canadian Air Force, has for a number of years been operating aircraft under the most severe and often hazardous winter conditions to develop anti-icing and de-icing equipment. During the past winter a North Star four-engined aircraft (DC4M) was made available to the Council by the R.C.A.F. to carry out some very intensive flying under icing conditions. Valuable performance data on the electro-thermal method of wing de-icing were obtained, and in order to make this information readily available to government departments and the aircraft industry generally in the United Kingdom, arrangements were made for the de-icing team, with their aircraft, to visit this country for most of August and part of September of this year. While here, the aircraft has been inspected by officials of the departments concerned with work of this type and has also been flown to those firms in the aircraft industry who are concerned. The numerous conferences have included visits to the Meteorological Office at which full information on both sides was exchanged. It is always a pleasure to discuss technical problems with people engaged on similar work elsewhere. As far as the meteorology of ice accretion is concerned, this pleasure has been heightened in the present case by the evident desire of our colleagues from the other side to give any information we wanted, and also by the fact that we found no substantial differences of opinion.

NEWS IN BRIEF

The L. G. Groves Memorial Prize for Meteorology has been awarded this year to F. Pasquill, D.Sc., Principal Scientific Officer, for successfully carrying out, at the School of Agriculture, Cambridge, an important investigation into the exchange of heat and water vapour between grassland and the stratum of air immediately above it. He devised the experimental method to be followed, designed and, in large measure, constructed the instruments, made the observations and carried out the reduction and analysis of his measurements.

This exceptionally varied ability, combined with a fine overall scientific attitude, has yielded results of much interest to the theory of turbulent diffusion and of great value in its application to evaporation problems as affecting agriculture, and the forecasting of visibility and fog as affecting aviation.

The L. G. Groves Memorial Award for Meteorological Air Observers has been won this year by Master-Pilot B. C. J. Calnan, R.A.F., for excellent services rendered as Meteorological Air Observer, No. 202 Squadron, Aldergrove. Master-Pilot Calnan has now completed over 90 meteorological sorties involving 820 hours flying. His technical ability and conscientious recording of scientific data have set a very high standard within the squadron. The meritorious service and devotion to duty displayed by this airman have rendered a most valuable contribution to the success of the long-range meteorological sorties carried out by this squadron.

REVIEW

Das Klima der Vorzeit. By M. Schwarzbach. $9\frac{1}{2}$ in. $\times 6\frac{1}{4}$ in., pp. viii + 211, *Illus.* Ferdinand Enke Verlag, Stuttgart, 1950. *DM.* 21.80.

The study of past climates, and especially of those catastrophic episodes known as "ice-ages", has probably been the most prolific breeding ground of theories in the history of science. Most of these theories broke down on some question of fact, for a full consideration of the facts requires a knowledge of almost every subject in and under the sun—astronomy, geology, biology, meteorology, physics, oceanography, are only a few. It also requires a very open mind. Most of the early theorists were men of one idea, and attributed every climatic change through a thousand million years to the action of a single cause, though great climatic changes were surely complex phenomena. Moreover, fifty years ago, when new theories were springing up almost every week, even the facts were inadequately known.

Dr. Schwarzbach's lucid, well illustrated and well documented book on the climate of the past should do much to help future theorists to acquire both an adequate background of knowledge and a due sense of caution. He begins with a good account of the founders and historical development of palæoclimatology and a chapter on the climate of the present in relation to the past. This chapter is short and rather superficial; if the author has a weakness it is in the field of modern meteorology. Then he gets down to business with "The reconstruction of past climates: the methods of palæoclimatology", in which the requisite basis of science has to be reinforced by the deductive faculties of a Sherlock Holmes. In turn he takes us through the evidence for heat and cold, drought and humidity, wind, thunder, seasons and climatic cycles. This section is well informed and up-to-date; for example the change in outlook in the interpretation of biological evidence is clearly brought out. Formerly the local climate of a particular geological period was inferred mainly from the climatic range of the living species of plants and animals which most closely resemble the fossil forms—a procedure beset with many pitfalls. Now greater importance is attached to the physiological character of the whole assemblage—size, rate of growth shown, e.g. by annual layers of corals, shape of leaves, etc., the inferences being based on the reaction of living species to various climates. The chemical and mechanical structure of the rocks themselves also provides a great deal of information. As a result we know the general climate and zonal differences of the various geological periods, and some curious details. One of

the oddest deductions, due to Lyell, is that since "fossil raindrops" have the same average diameter as the impressions left by raindrops now, the density of the atmosphere has not changed appreciably. Lithology even gives us a few fossil "upper winds" in the form of distributions of volcanic ash relative to the parent volcanoes. Thus some 270 million years ago, during an eruption, the upper winds at Edinburgh blew mainly from north. In the realm of climatic cycles the most interesting result is the permanence of the sunspot cycle.

This solid body of evidence is then applied to writing the climatic history of the earth period by period since the first well recorded glaciation more than 500 million years ago. This chapter covers 70 pages packed with information. A general summary includes diagrams to show the migrations of the desert belt of the northern hemisphere (salt deposits) and the coral belt, and a diagrammatic representation of earth history.

The author next turns to the subject of causes, in a chapter which he somewhat cynically heads with a quotation from "Faust": "Don't worry—it was only thought". He runs rapidly through the familiar list—cooling earth, radio-activity, configuration, salt content of the oceans, cloud, carbon dioxide, volcanic ash, continental drift, changes of the earth's orbit, interstellar space, changes of solar radiation. There have been a few more—the whole gamut ranges from the sublime to the ridiculous—but he has mercifully spared us the more ridiculous. His keynote throughout is caution; we do not even yet know enough of the facts to make a final choice. In particular, geologists still tend to think of the whole of a formation, covering many millions of years, as a single episode, though within such a long period there must have been many changes, some of them quite large. He concludes that the Permo-Carboniferous glaciation of the equatorial regions is inexplicable except by movements of the poles, but since then these have played no part, and on the whole he favours R. F. Flint's "solar-topographic hypothesis".

Whatever the causes, the climatic future of the earth is still anybody's guess. As he says, the reader has a free choice between the cheerful optimism of Köppen, "For the next 20,000 years or more the recurrence of an ice-age in the northern hemisphere is excluded by astronomical data," and the gloomier prognosis of Brooks, "Some thousands of years hence ice will again spread out from Norway and the Alps."

C. E. P. BROOKS

BOOKS RECEIVED

Iminência duma " grande " sêca Nordestina. By J. de Sampaio Ferraz. *Rev. brasil. Geogr.*, Ano XII, No. 1. $10\frac{1}{2}$ in. $\times 7\frac{1}{4}$ in., pp. 16. Conselho Nacional de Geografia, Rio de Janeiro, 1950 (English summary).

Contribuicao ão Estudo do Clima do Rio Grande do Sul, By F. P. Machado. $11\frac{1}{2}$ in. $\times$ $8\frac{1}{4}$ in., pp. viii + 91. Conselho Nacional de Geografia, Rio de Janeiro, 1950.

Indian Journal of Meteorology and Geophysics. India Meteorological Department. Vol. 1, No. 3, July 1950. Manager of Publications, Delhi, 1950. *Rs.* 2-4 or 3*s.* 9*d.*

Jaarboek, A, Meteorologie, 1946 *and* 1947. Koninklijk Nederlands Meteorologisch Instituut. No. 97, $13\frac{1}{4}$ in. $\times$ $9\frac{1}{2}$ in., pp. xii + 92 and xii + 94. Staatsdrukkerij-en Uitgeverijbedrijf's-Gravenhage, 1949. Price: *fl.* 5.00 each.

Onweders. Optische Verschijnselen, enz., in Nederland. Naar vrijwillige Waarnemingen in 1944. Deel LXV. Koninklijk Nederlands Meteorologisch Instituut. No. 81, $9\frac{1}{2}$ in. × $6\frac{3}{4}$ in., pp. 58. Staatsdrukkerij-en Uitgeverijbedrijf's-Gravenhage, 1949. Price *fl.* 2.00.

ERRATUM

October 1950, page 281, line 35 :

$$for \text{ ``} e = \frac{2qH}{(H^2 + y^2)^{3/2}} = \frac{M}{r^{3/2}} \text{''} \quad read \text{ ``} e = \frac{2qH}{(H^2 + y^2)^{3/2}} = \frac{M}{r^3} \text{''}$$

METEOROLOGICAL OFFICE NEWS

Kew Observatory.—Among the many distinguished Superintendents of Kew Observatory, the name of Whipple has appeared twice. G. M. Whipple held the appointment from 1876 to 1893, and his son, F. J. W. Whipple, from 1925 to 1939. A brother of the latter, Mr. R. S. Whipple, has recently offered to provide a memorial, to be set up in Kew Observatory, in commemoration of past Superintendents. This generous offer has been gladly accepted, and discussions are now taking place with Mr. Ernest Gillick, A.R.A., about the form and design of the memorial. It will probably be placed in the beautiful period room which constitutes the Superintendent's Office.

Mr. Whipple has also kindly offered to establish a memorial to Robert Beckley, his grandfather, who worked at Kew Observatory from 1853 to 1872. Robert Beckley is well known to meteorologists as the inventor of the anemometer and rain gauge which bear his name, and which were in operation at Kew for a long time. The memorial plate to him, which is also being designed by Mr. Gillick, will probably be erected in the octagonal entrance hall of the Observatory.

Forecasting during the War.—The following letter from Marshal of the Royal Air Force, Sir Arthur Harris, G.C.B., O.B.E., A.F.C., appeared in *The Aeroplane* for September 22, 1950.

Scotching a Canard

A statement in your issue of June 9 last has been brought to my notice, in which you repeat an ancient canard that has been circulated on other occasions elsewhere, alleging that I once told a Meteorological Officer that I " would have had over 50 per cent. correct forecasts if I had disregarded the official forecasts entirely."

To this story, in which there is not a word of truth and which has been so often repeated, I would now ask you to give my official denial. It is not only untrue but it is a gross and entirely undeserved reflection on a body of men who rendered sterling service to Bomber Command throughout the War. Upon their devotion and skill I not only placed the utmost reliance, but they proved themselves by their skill the major factor in saving the lives of an unpredictable but large number of air crew, who would otherwise inevitably have perished from the hazards of the European climate.

I would be glad, therefore, if you will make this disclaimer on my behalf and do something towards preventing the further circulation of this silly and lying story, which no doubt causes as much distress to the Meteorologists concerned as it does to me.

ARTHUR T. HARRIS

Cape Town, S.A. (Marshal of the R.A.F.)

We offer our acknowledgements and thanks to *The Aeroplane* for permission to give this letter the wider distribution amongst meteorologists which reproduction in the *Meteorological Magazine* makes possible.

Forecasts for food research.—As a result of casual observations made over the past two years, it was suspected by the food research department of Lever

Bros. and Unilever Ltd., that a relationship existed between high humidity and the incidence and spread of a fungus disease, "downy mildew", in spinach plants. As a consequence, the Company decided to try applying protective fungicidal sprays to the spinach plants before the onset of fog or very low cloud in the district where the crop is grown. Special forecasts were supplied by the Central Forecasting Office, which it is understood have assisted towards a solution of the problem.

Examination successes.—We offer congratulations to the following on their recent successes:—

Mr. R. H. Eldridge and Mr. D. W. Newton, who have obtained the M.Sc. degree of London University in Meteorology.

Mr. J. E. Atkins, who passed the Intermediate B.Sc. examination of London University.

Retirement.—The Office is losing the services of Miss E. G. Johnson, who is retiring at the early age of 50 at her own request. Miss Johnson has spent the last thirteen years in the branch which deals with staff: her wide experience and sympathetic understanding of the problems affecting assistant staff will be greatly missed. Our good wishes go with her.

Meteorological Office, Aden.—Mr. J. A. McFarlane, posted to the radio-sonde unit at Aden early this year, is a Highlander and a piper, and speedily found his talents much in demand. His reputation spread and came to the ears of the Sultan of Lahej, a city about thirty miles distant from Khormaksar airfield. The Sultan's private pipers were in need of some coaching since the piper from Scotland, who originally taught them, had returned to his native land. Mr. McFarlane now rejoices in the title of Honorary Pipe-Major to His Highness the Sultan of Lahej and on most Sundays the Sultan's car fetches him to Lahej where for an hour or two he coaches His Highness's pipers. He is accompanied by Sergeant Collins of the R.A.F. Regiment who trains the drummers.

WEATHER OF SEPTEMBER 1950

Mean pressure was above 1015 mb. over a region extending from central Europe and the western Mediterranean across the Azores, the United States and Vancouver, and within this region was above 1020 mb. over a considerable area westward of Portugal. It was relatively low from southern Greenland eastwards to Finland, and over the Greenland Sea, being lowest (about 995 mb.) between Iceland and the Faeroes. Mean pressure was below the normal for September over Europe, except in the south-west of France and in Spain and Portugal, the deficit exceeding 10 mb. over an area including the Faeroes, Scotland, southern Sweden and most of Norway. Deviations from normal were generally small in the north of Africa and in North America.

In the British Isles the weather was excessively wet, exceptionally so in Northern Ireland, Scotland and the western districts of England and Wales. Locally in the Cumbrian mountains the total rainfall for the month was more than 40 in.; in contrast, on the north coast of Kent one or two places received only 1·4 in. The month was very unsettled, with rather frequent and at times severe gales, and sunshine was appreciably below the average on the whole.

During the first five days small secondary depressions or troughs of low pressure moved over the British Isles. Rain fell in most areas, being rather

heavy at times in the west and north. It was generally sunny, however, on the 2nd and at most places on the 5th. On the 6th a depression westward of Ireland moved rapidly north-east across Scotland and deepened, causing widespread gales, severe locally, and heavy rain (4·25 in. at Ulpha, Cumberland 4·00 in. at Cwm Dyli, Snowdon, and 3·72 in. at Thirlmere, Cumberland). On the 7th, gales were recorded in the north of Scotland and showers occurred, chiefly in the north-west, but records of bright sunshine were good generally. Again, on the 8th and 9th, a small secondary depression south-westward of Ireland moved north-east to southern Scotland and thence east to Denmark; heavy rain occurred in southern England on the 8th and in Northern Ireland and parts of Scotland on the 10th and 11th.

A spell of very unsettled weather set in on the 13th, when a secondary disturbance south-westward of Ireland moved north-north-east and deepened, subsequently turning north-east. Gales were registered at exposed stations in the west on the 13th and in the north of Scotland on the 14th, while rain fell generally on the 13th and showers, with local thunderstorms in the west, on the 14th (2·89 in. at Fort William on the 14th). From the 15th to the 18th an intense depression moved north-east from mid Atlantic to the south-west of Scotland, and then irregularly north-north-east, to the west of Norway. Widespread, severe gales occurred in the British Isles on the 16th and 17th and heavy rainfall was registered in the west (2·86 in. at Glenbranter, Argyll, on the 16th and 2·74 in. at Glengavel Reservoir, Lanarkshire, on the 17th). On the 19th a small depression off the mouth of the English Channel moved east, while another approached the Hebrides and subsequently moved very slowly across Scotland; rain fell on the 19th and there were showers and local thunderstorms on the 20th and 21st. A complex depression approached our north-west coasts on the 23rd and later moved across the country; very heavy rain occurred in some parts and thunderstorms were recorded in the east of Great Britain on the 24th and 25th (4·14 in. at Hafod Fawr and 4·02 in. at Blaenau Festiniog, both in Merioneth, on the 23rd, 5·15 in. at Llydaw Intake, Snowdon, 4·23 in. at Pandyrddrywyrd, Merioneth, and 3·13 in. at Dundee Harbour on the 24th and 4·31 in. at Llydaw Intake on the 25th). A ridge of high pressure moving east over the British Isles on the 26th was associated with a mainly fair day in England and Wales but further rain occurred later in Scotland and Ireland. In the closing days of the month a depression developed south-westward of Ireland and moved east, later turning north-north-east; rain fell again in most parts of the British Isles and was heavy locally on the 30th.

The general character of the weather is shown by the following provisional figures:—

	Air Temperature			Rainfall		Sunshine
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average
	°F.	°F.	°F.	%		%
England and Wales ...	76	31	−0·5	196	+9	79
Scotland	71	28	−0·5	257	+9	87
Northern Ireland ...	69	35	−0·5	256	+10	82

RAINFALL OF SEPTEMBER 1950

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square ...	2·47	136	*Glam.*	Cardiff, Penylan ...	6·75	221
Kent	Folkestone, Cherry Gdn.	2·60	110	*Pemb.*	St. Ann's Head... ...	...	...
,,	Edenbridge, Falconhurst	2·98	131	*Card.*	Aberystwyth	5·79	209
Sussex	Compton, Compton Ho.	4·63	166	*Radnor*	Tyrmynydd	9·89	231
,,	Worthing, Beach Ho. Pk.	3·11	145	*Mont.*	Lake Vyrnwy	12·21	330
Hants.	Ventnor, Roy. Nat. Hos.	3·78	152	*Mer.*	Blaenau Festiniog ...	22·14	281
,,	Bournemouth	3·17	136	*Carn.*	Llandudno	4·62	217
,,	Sherborne St. John ...	2·93	143	*Angl.*	Llanerchymedd ...	8·96	305
Herts.	Royston, Therfield Rec.	2.90	154	*I. Man*	Douglas, Borough Cem.	10·38	318
Bucks.	Slough, Upton... ...	2·47	140	*Wigtown*	Port William, Monreith	8·14	279
Oxford	Oxford, Radcliffe ...	2·86	167	*Dumf.*	Dumfries, Crichton R.I.	8·47	313
N'hants.	Wellingboro' Swanspool	3·60	200	,,	Eskdalemuir Obsy. ...	12·16	329
Essex	Shoeburyness	2·37	142	*Roxb.*	Kelso, Floors	4·31	227
,,	Dovercourt	2·53	141	*Peebles*	Stobo Castle	7·17	285
Suffolk	Lowestoft Sec. School...	2·58	132	*Berwick*	Marchmont House ...	4·16	173
,,	Bury St. Ed., Westley H.	3·20	161	*E. Loth.*	North Berwick Res. ...	4·56	218
Norfolk	Sandringham Ho. Gdns.	3·15	152	*Mid'ln.*	Edinburgh, Blackf'd. H.	4·75	232
Wilts.	Bishops Cannings ...	3·85	176	*Lanark*	Hamilton W. W., T'nhill	7·84	293
Dorset	Creech Grange... ...	4·97	182	*Ayr*	Colmonell, Knockdolian	11·33	327
,,	Beaminster, East St. ...	5·00	196	,,	Glen Afton, Ayr San. ...	12·49	320
Devon	Teignmouth, Den Gdns.	3·56	182	*Bute*	Rothesay, Ardencraig ...	11·43	282
,,	Cullompton	4·78	212	*Argyll*	L. Sunart, Glenborrodale	...	...
,,	Ilfracombe	7·39	275	,,	Poltalloch	12·50	274
,,	Okehampton Uplands	8·12	251	,,	Inveraray Castle ...	17·80	227
Cornwall	Bude, School House ...	5·74	232	,,	Islay, Eallabus... ...	10·43	250
,,	Penzance, Morrab Gdns.	6·08	207	,,	Tiree	9·15	247
,,	St. Austell	7·12	223	*Kinross*	Loch Leven Sluice ...	7·31	264
,,	Scilly, Tresco Abbey ...	4·46	174	*Fife*	Leuchars Airfield ...	5·87	304
Glos.	Cirencester	5·05	229	*Perth*	Loch Dhu	16·06	280
Salop.	Church Stretton ...	5·14	244	,,	Crieff, Strathearn Hyd.	8·01	280
,,	Cheswardine Hall ...	...	...	,,	Pitlochry, Fincastle ...	5·83	232
Worcs.	Malvern, Free Library	3·54	183	*Angus*	Montrose, Sunnyside ...	5·96	299
Warwick	Birmingham, Edgbaston	4·85	271	*Aberd.*	Braemar	6·62	264
Leics.	Thornton Reservoir ...	3·15	174	,,	Dyce, Craibstone ...	6·10	252
Lincs.	Boston, Skirbeck ...	3·74	212	,,	Fyvie Castle	5·34	205
,,	Skegness, Marine Gdns.	2·95	163	*Moray*	Gordon Castle	6·22	249
Notts.	Mansfield, Carr Bank...	3·78	205	*Nairn*	Nairn, Achareidh ...	4·18	198
Derby	Buxton, Terrace Slopes	6·40	198	*Inverness*	Loch Ness, Garthbeg ...	7·49	242
Ches.	Bidston Obersavory ...	4·82	200	,,	Glenquoich	20·55	298
Lancs.	Manchester, Whit. Park	...	...	,,	Fort William, Teviot ...	14·85	232
,,	Stonyhurst College ...	7·23	189	,,	Skye, Duntuilm ...	9·62	209
,,	Squires Gate	6·19	228	*R. & C.*	Tain, Tarlogie House ...	5·67	248
Yorks.	Wakefield, Clarence Pk.	2·48	155	,,	Inverbroom, Glackour...	14·12	320
,,	Hull, Pearson Park ...	2·69	156	,,	Applecross Gardens ...	11·18	224
,,	Felixkirk, Mt. St. John...	3·33	183	,,	Achnashellach	15·87	231
,,	York Museum	2·65	163	,,	Stornoway Airfield ...	7·09	189
,,	Scarborough	2·38	133	*Suth.*	Loch More, Achfary ...	19·35	337
,,	Middlesbrough... ...	2·33	140	*Caith.*	Wick Airfield	4·81	192
,,	Baldersdale, Hury Res.	5·32	213	*Shetland*	Lerwick Observatory ...	5·58	185
Norl'd.	Newcastle, Leazes Pk....	3·08	156	*Ferm.*	Crom Castle	6·97	250
,,	Bellingham, High Green	5·60	233	*Armagh*	Armagh Observatory ...	5·57	226
,,	Lilburn Tower Gdns. ...	3·93	167	*Down*	Seaforde	6·23	227
Cumb.	Geltsdale	6·07	217	*Antrim*	Aldergrove Airfield ...	5·98	241
,,	Keswick, High Hill ...	14·51	343	,,	Ballymena, Harryville...	8·69	279
,,	Ravenglass, The Grove	8·59	255	*L'derry*	Garvagh, Moneydig ...	8·26	278
Mon.	Abergavenny, Larchfield	3·79	162	,,	Londonderry, Creggan	8·41	255
Glam.	Ystalyfera, Wern House	13·54	310	*Tyrone*	Omagh, Edenfel ...	8·86	290